Maintenance/monitoring/enforcement considerations

a. Reliability and Consistency over Time
- The key is proper design and maintenance.

b. Routine and Non-routine Maintenance
- Routine maintenance consists of standard turf maintenance.
- Non-routine maintenance consists of turf replacement, soils replacement, and regrading.

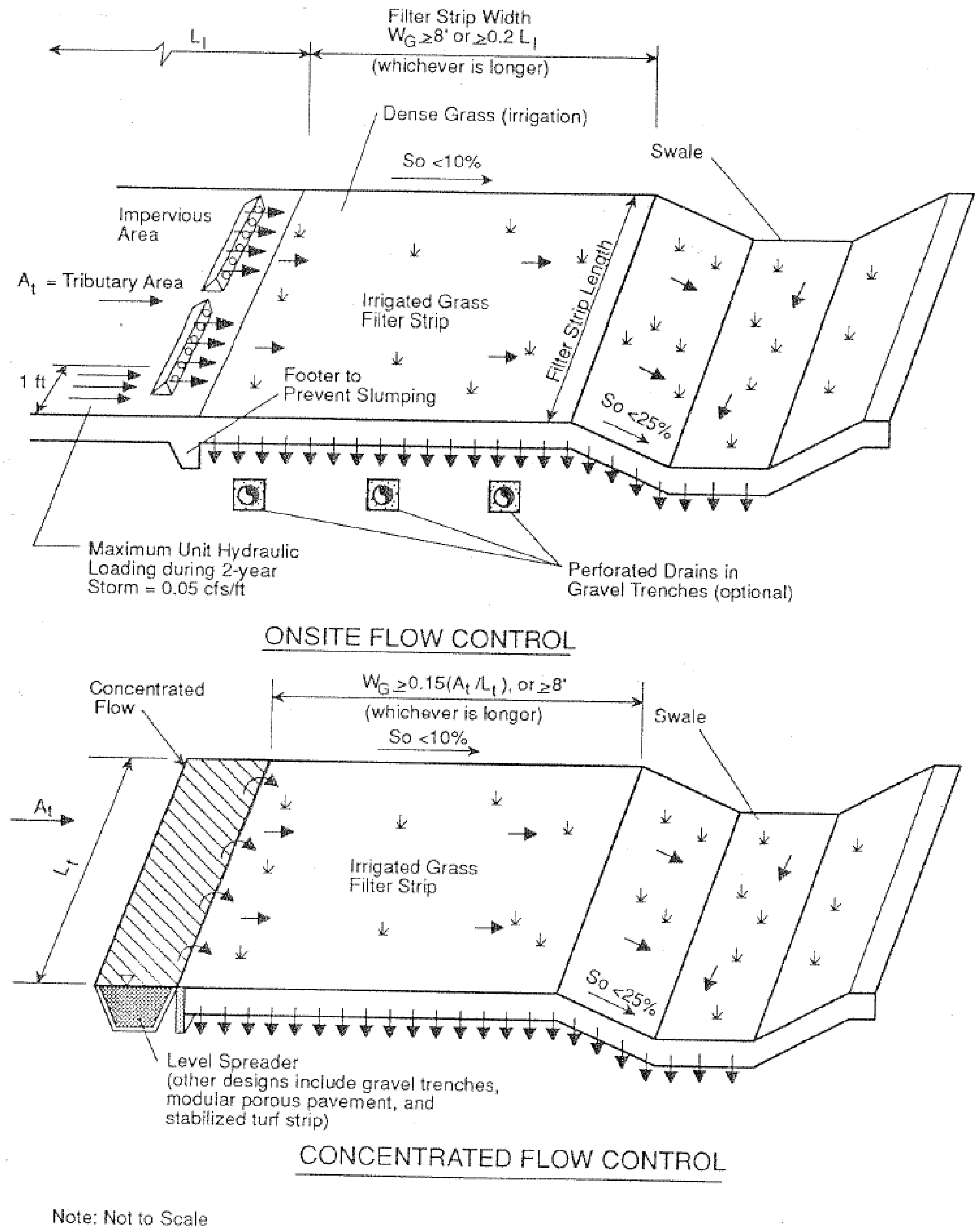


Figure 8-10 Onsite and Offsite Applications of Grass Filter Strips

Source: Denver Urban Drainage and Flood Control District, 1992

8.3.4.6 Sand Filters

In its simplest form, a sand filter is a self-contained bed of sand into which the first flush of runoff is diverted. The water is filtered as it passes through the sand, much like a slow sand filtration system for drinking water supply. The effluent is typically collected with perforated pipe and discharged to a stream or channel.

Sand filters are often placed at the outlet of detention basins to improve effluent water quality. Enhanced sand filters use layers of peat, limestone, and/or topsoil to improve removal rates. Sand trench systems are used to treat parking lot runoff, and these include the Austin sand filter and the Shaver design.

A new modification of the sand filter concept is the biofiltration pond. Using a media which has a cation exchange capacity of at least 10 milli-equivalents per 100 grams will improve metals capture (WEI, 1994). Although sand is still the predominant media of choice, clays and other compounds may be included to attain high pollutant removal rates while still providing ample drainage for the design storm event. This can typically be accomplished using a gradation of filter media, decreasing in size with depth.

General applicability and experience with technique elsewhere

a. Typical Applications
- Sand filters have been successfully used in diverse applications for small (less than 10 acres) tributary areas (Debo, 1994).
- Recommended for "ultra-urban" areas where area is limited and runoff is poor quality; not recommended for new construction sites.
- Most sand filters are limited to an impervious tributary area of 5 to 10 acres. Follow-up sand filters, placed at the outlet of detention basins, may treat tributary areas in excess of 100 acres (Urbonas and Ruzzo, 1986).

b. Design Considerations (See Figure 8-11 for representative schematic)
- Inlet structure should be designed to spread the flow uniformly across the surface of the filter media.
- Riprap or other dissipation devices should be installed to prevent gouging of the sand media and to promote uniform flow.
- Final sand bed depth should be at least 18 inches.
- Underdrain pipes should consist of main collector pipes and perforated lateral branch pipes.
- The underdrain piping should be reinforced to withstand the weight of the overburden.
- Internal diameters of lateral branch pipes should be 4 inches or greater and perforations should be 3/8 inch.
- Maximum spacing between rows of perforations should not exceed 6 inches.
- All piping should be schedule 40 polyvinyl chloride or greater strength.
- Minimum grade of piping should be 1% slope.
- Access for cleaning all underdrain piping should be provided.
- A presettling basin and/or biofiltration swale is recommended to pretreat runoff discharging to the sand filter.
- A maximum spacing of 10 feet between lateral underdrain pipes is recommended.
- The primary purpose of the sand filter is to improve stormwater quality; they have a limited ability to reduce peak flows.
- The retrofitting of sand filters has been performed in several applications (Schueler et al. 1992).

c. Other Experiences with BMP
- Of the nearly 1000 sand filters installed since the early '80s in the Austin, Texas area, the vast majority are working to design specifications and very few have failed (Schueler et al., 1992)

Reported pollutant removal efficiencies

- Reported data:

Pollutant	Removal Rate (%)
Total Phosphorus	65
Lead	50-70
BOD	60
Sediment	85
Total Nitrogen	50
Zinc	60-80
COD	80
Bacteria	50-60

- Sand/peat beds have higher removal effectiveness due to adsorptive properties of peat.
- Designs incorporating vegetative cover on the filter bed increase nutrient removal.
- Pretreatment (sedimentation or oil and grease removal) will enhance the performance of the filter and will decrease the maintenance frequency required to maintain effective performance.
- The sand filter does not rely on infiltration to remove peak stormwater flows or improve effluent quality. At the same time it does appear to have good removal rates of most pollutants (with the possible exception of nitrogen), with the potential to increase removal efficiencies through the addition of other media such as peat, clays, limestone, and grass cover. The use of sand with high iron content also may improve efficiencies.

Advantages

- Since infiltration is not a significant mechanism, ground water protection is maximized.
- This BMP has a proven performance record in a variety of applications.

Disadvantages

a. Human Risk, Public Safety and Potential Liability
   - Basin should be grated to prevent unauthorized entry.

b. Environmental Risk and Implications
   - Since the removed sand has been demonstrated to be non-toxic, and there is no evidence that resuspension of contaminated sediment is a problem, there is little concern for environmental problems with this BMP.

c. Other
   - Larger sand filters with no vegetative cover may be unattractive; the surface can be extremely unattractive and some have caused odor problems.
   - Sand filters are primarily for stormwater quality mitigation, not quantity or peak flow mitigation.

Maintenance/monitoring/enforcement considerations

a. Routine and Non-routine Maintenance
   - The primary routine maintenance is debris removal and scraping of the upper sand layer. This is mostly manual work.
   - Non-routine maintenance includes resanding (replacement of the sand) after enough sand has been removed that significant breakthrough occurs. In the case of the Shaver design in which a sedimentation basin is included, this must be cleaned out when the basin loses its holding capacity.

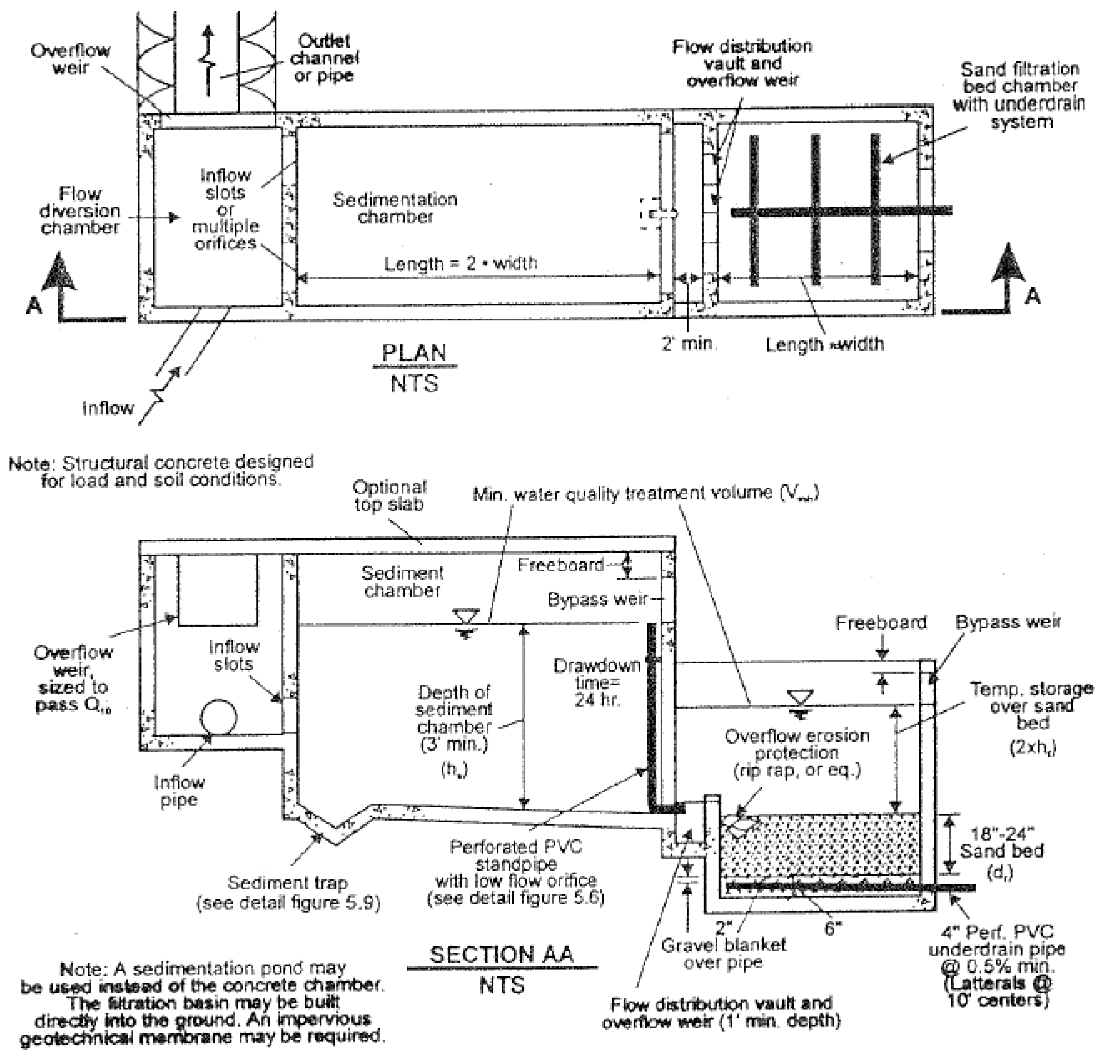


Figure 8-11 Sand Filtration Basin

Source: Center for Watershed Protection, 1996

8.3.4.7 Infiltration Trenches

Infiltration trenches can be generally described as a part of an open ditch that encourages rapid infiltration of runoff to the ground water through the placement of materials with high hydraulic conductivities. The trench is basically an excavated area within the ditch into which clean gravels are placed. The ditch should provide for slow flow rates to allow settling of suspended solids as well as the opportunity for substantial infiltration of the total intercepted flow.

General applicability and experience with technique elsewhere

a. Typical Applications
- As an infiltration type BMP, use should be limited to those areas where ground water levels are well below the bottom of the trench and there is significant retention time in the soils before reaching ground water.
- Commonly, infiltration trenches are sized to intercept and dispose of runoff from a specific design storm (typically 2-year storms).

b. Design Considerations (See Figure 8-12 for representative schematic)
- Use in drainage areas less than 15 acres.
- Soils that are suitable for infiltration systems are silt loam, loam, sandy loam, loamy sand, and sand.
- Soils that have a 30 percent or greater clay content are not suitable for infiltration trenches.
- The soil infiltration rate should be between 0.5 and 2.4 inches per hour.
- The use of infiltration systems on fill is not allowed due to the possibility of creating an unstable subgrade.
- A minimum of 3 feet between the bottom of the infiltration trench and the groundwater table is recommended.
- Site slope should be less than 20 percent and trench should be horizontal.
- The proximity of building foundations should be at least 10 feet upgrade.
- A minimum of 100 feet should be maintained from water supply wells when the runoff is from industrial or commercial areas.
- Water quality infiltration trenches should be preceded by a pretreatment BMP.
- The aggregate material for the trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches.
- The aggregate should be graded such that there will be few aggregates smaller than the selected size. For design purposes, void space for these aggregates may be assumed to be in the range of 30 percent to 40 percent.
- The aggregate should be completely surrounded with an engineering filter fabric. If the trench has an aggregate surface, filter fabric should surround all aggregate fill material except for the top one foot.
- Bypass larger flows.
- To reduce clogging of the trench with sediments, a sump pit or a filter strip and flow spreader should be used to treat water entering the ditch.
- Since infiltration is the primary mechanism for pollutant removal from runoff, the infiltration trench could actually impair ground water quality in fast-draining soils. Some biological uptake of nutrients may occur in well-vegetated ditches, and removal of sediments will remove some associated heavy metals.
- The most important aspect to the potential for success of an infiltration trench is ground water levels. If the trench is easily inundated by high ground water levels or ground water mounding due to infiltration of runoff, the trench will simply become an open channel. Thus, the trench can fail in two modes; high infiltration rates to ground water that is near the base of the trench, or low infiltration rates due to poor draining soils or clogging of the trench with sediments.
- Infiltration trenches work well for residential lots, commercial areas, parking lots, and open space areas.
- Infiltration systems should not be constructed until all construction areas draining to them are fully stabilized.

Stormwater BMPs

- An analysis should be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots, or sloping sites.

c. Other Experiences with BMP

- In a Maryland study (Galli, 1992) of 38 infiltration trenches, losses of infiltration capacity were caused by high water tables, poorly draining soils, and inadequately sized filter strips.
- As mentioned previously, the term 'infiltration trench' implies that runoff water is intercepted and directed to the ground water. Unless other BMPs are included to remove pollutants before the runoff enters the trench, ground water quality may be compromised. However, Urbonas and Stahre (1993) state that data available so far shows that ground water quality does not degrade noticeably due to infiltration of stormwater from residential and many types of commercial developments. Filtration, adsorption, and ion exchange may occur in the underlying soils.

Reported pollutant removal efficiencies

- Removal rates have been estimated by Schueler (1987) using assumed efficiencies and modeling. These show very high removal rates for TSS, Nitrogen, Phosphorous, Zinc and BOD.

Advantages

- The combination of water conveyance, runoff reduction, lowering of peak flows, and pollutant removal make this an effective BMP.

Disadvantages

a. Human Risk, Public Safety and Potential Liability

- Minimal

b. Environmental Risk and Implications

- The use of infiltration as the primary pollutant reduction mechanism may increase ground water contamination by highly soluble contaminants in fast-draining soils and/or high water level conditions.

c. Other

- If a trench becomes clogged with sediments, it simply stops functioning. The gravel must be removed and replaced with clean gravel, and it may be necessary to remove soils lining the trench which have also become clogged. The Maryland study (Galli, 1992) gave the following results for 38 trenches averaging 2.4 years old (maximum 5.1 years):

	Operating as designed?		
Pre-treatment type	Yes	No	Unknown
Sump Pit	48.4%	42.0%	9.6%
Grass Filter	42.9%	57.1%	0.0%
TOTAL	47.4%	44.7%	7.9%

- Conversely, a state survey of infiltration devices in Maryland in 1986 showed 80% of the infiltration trenches working as designed (Clement and Pensyl, 1987). These results are questionable, however, as 50% of the trenches had no observation wells to determine if there was standing water under the gravel. Such trenches were reported as operating properly even though this primary evaluation criteria could not be determined.

Maintenance/monitoring/enforcement considerations

a. Reliability and Consistency over Time
- If non-routine maintenance is performed correctly, there should be little degradation in performance

b. Routine and Non-routine Maintenance
- Routine maintenance includes debris and litter removal and control of overgrown vegetation.
- Non-routine maintenance involves a clogged trench which requires complete removal and replacement of the gravel as well as surrounding clogged native soils. This can be greatly reduced by proper design and routine maintenance.

c. Sustainability of Maintenance or Program Management
- If the trench becomes fully clogged, complete rehabilitation may cost as much as initial construction; if funding is private, the trench may go unrepaired.

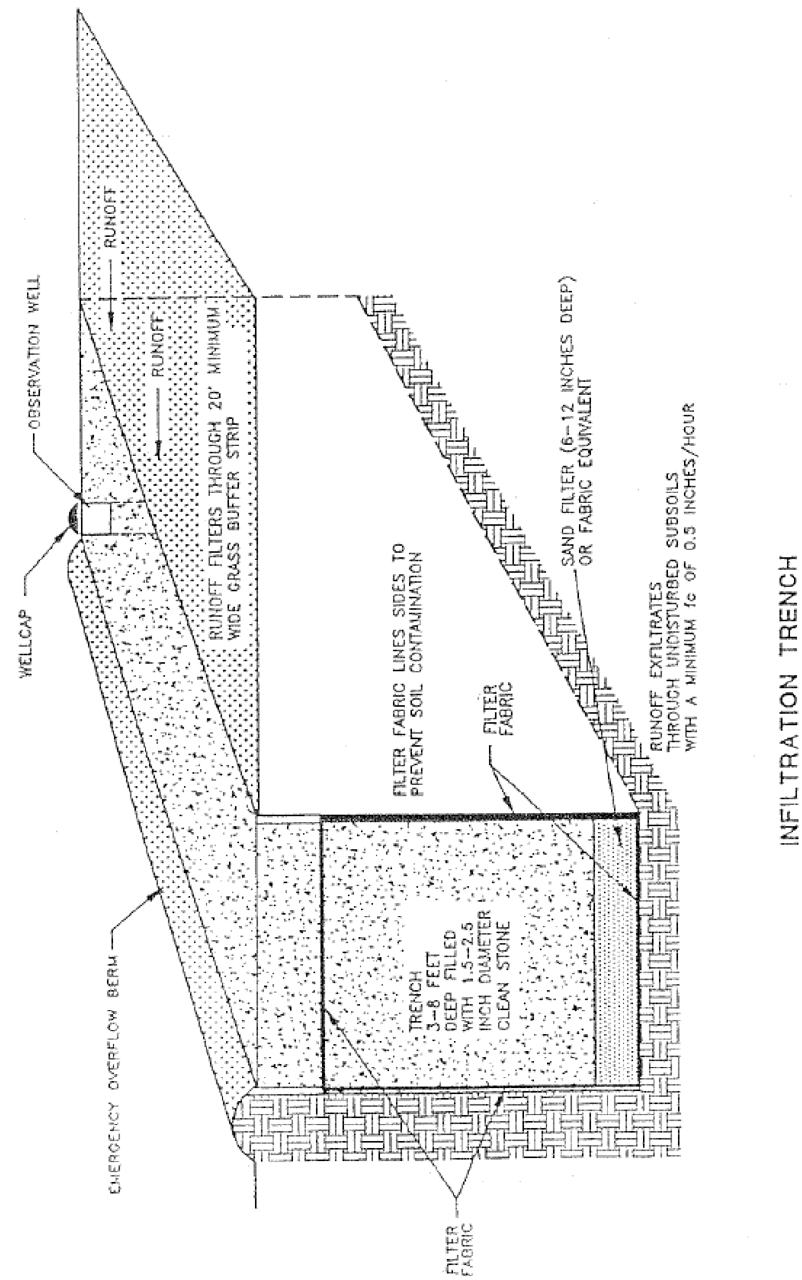


Figure 8-12 Infiltration Trench

Source: Stormwater Management Manual For The Puget Sound Basin

8.3.4.8 Porous Pavement

There are two forms of porous pavement: modular block, which is made porous through its structure, and poured-in-place concrete or asphalt which is porous due to the mix of the materials.

Modular block porous pavement consists of perforated concrete slab units underlain with gravel. The surface perforations are filled with coarse sand or sandy turf. It is used in low traffic areas to accommodate vehicles while facilitating stormwater runoff at the source. It should be placed in a concrete grid that restricts horizontal movement of infiltrated water through the underlying gravels.

Poured-in-place porous concrete or asphalt is generally placed over a substantial layer of granular base (Urbonas and Stahre, 1993). The pavement is similar to conventional materials, except for the elimination of sand and fines from the mix.

If infiltration to ground water is not desired, a liner may be used along with perforated pipe and a flow regulator to slowly drain the water away over a 6 to 12 hour period.

General applicability and experience with technique elsewhere

a. Typical Applications
- This is exclusively an on-site BMP that should never be used for treating water with high sediment loads. This is particularly true for porous concrete or asphalt, which are primarily designed to remove pollutants deposited on the pavements from the atmosphere (Schueler, 1987)
- Modular block pavement is applicable to low traffic zones and permeable upper soils with ground water no less than 4 feet from the gravel bedding.
- The use of porous concrete or asphalt is not well-received in colder climates where freeze-thaw cycles may fracture the pavement. Despite this, it has been found that properly designed systems are not damaged by such processes (Debo, 1994).

b. Design Considerations (See Figures 8-13 and 8-14 for representative schematics)
- Either form of porous pavement must be limited to low traffic areas with limited deposition of clays and fines which could clog the pavement.
- As infiltration is the primary mechanism of pollutant removal, areas with high ground water vulnerability may not be good choices for this BMP.
- Large soil surface areas are needed for maximum exfiltration and pollutant removal.
- Soil infiltration rate should be greater than 0.27 inches per hour and clay content less than 30 percent.
- Only feasible on sites with gentle slopes (less than 5%).
- Design infiltration rate should be equal to ½ of the infiltration rate determined from soil textural analysis.
- Minimum of 3 feet between stone reservoir level and seasonally high water table.
- Should not be constructed over fill soils.
- Vegetative strip or diversion berm required to protect pavement area from off-site runoff before, during, and after construction.
- If porous pavement areas receive runoff from off-site areas, a pretreatment facility should be constructed to remove oil, grit, and sediments before entering the porous pavement.
- Dry subgrade should be covered with engineering filter fabric such as Mirafi #14N or equal on bottom and sides.
- Pavement section consisting of 4 layers as shown on Figure 8-9.
- Stone should be clean, washed, stone meeting roadway standards.
- Reservoir base course should consist of 1" to 3" crushed stone aggregate compacted lightly at the depth required to achieve design storage.
- Filter courses to be ½" crushed stone aggregate at a 1" to 2" depth.
- Surface course should be laid in 1 lift at the design depth with compaction done while the surface is cool enough to resist a 10-ton roller. Only 1 or 2 passes are required.

- After final rolling, no vehicular traffic should be permitted on pavement until cooling and hardening, a minimum of 1 day.
- Stone reservoir should be designed to completely drain within a maximum of 2 to 3 days after design storm event.
- The porous pavement site should be posted with signs indicating the nature of the surface and warning against resurfacing, using abrasive, and parking heavy equipment.
- An observation well should be installed on the downslope end of the porous pavement area to monitor runoff clearance rates. The observation well should consist of perforated PVC pipe, 4 to 6 inches in diameter, constructed flush with the ground. The top of the observation well should be capped to discourage vandalism and tampering.
- Limited in application to parking lots, service roads, emergency and utility access lanes, and other low traffic areas.
- Limited to sites between 1/4 acre and 10 acres.
- Should not be constructed near groundwater drinking supplies.
- Heavy equipment should be prevented from compacting the underlying soils before and during construction.

c. Other Experiences with BMP

- Modular block BMPs have been in use since the mid-1970's. Field data is lacking to quantify long-term performance as an infiltration device, but anecdotal evidence indicates it is reliable. Pratt (1990) found that if excessive sediment deposition is controlled, modular paved surfaces can function for at least 15 years.
- Anecdotal experience indicates that unless careful cleaning with vacuum cleaners is performed on a frequent basis, the pavement will seal within 1-3 years. Ultimately, it will seal anyway and cannot be repaired; the only option appears to be replacement. (Urbonas and Stahre, 1993). Porous pavement sites have one of the highest failure rates of any BMP. At the same time, when working properly it can be a very cost-effective BMP for commercial sites.
- As infiltration is a primary mechanism, the potential for pollutant discharge to ground water, particularly soluble pollutants, is significant. Additionally, there is concern that hydrocarbons may be leached from asphalt material, thereby increasing the contaminant load.

<u>Reported pollutant removal efficiencies</u>

- Reported data

  Representative long-term pollutant removal rate for porous pavement sites designed for the 2-year storm are as follows (Debo, 1995):

Pollutant	Removal Rate (%)
Total Phosphorus	65
Lead	98
Sediment	95
Total Nitrogen	85
COD	82
Zinc	99

- Suspended sediment and associated metals, oil and grease removal may be high, as long as the pavement remains porous. Removal rates estimates vary from 0 to 95 percent. Soluble constituent removal is likely lower, depending on the materials used. Filtration, adsorption, and ion exchange may occur in the underlying soils. With good drainage, soluble constituents are likely to show low removal efficiencies (UDFCD, 1992).

Advantages

- Low maintenance for modular block pavement.
- Slows and reduces runoff, reducing the need for expensive detention facilities.

Disadvantages

a. Environmental Risk and Implications
- Fast draining soils can encourage ground water pollution from soluble metals and other pollutants.
- Risk can vary from very minor to great, depending on how well the system is functioning

b. Other
- Large silt and sand loads (e.g. from construction sites) may accelerate the clogging of the pavement pores, requiring expensive removal of sediments.
- Porous concrete or asphalt tends to seal in 1-3 years unless vacuum cleaning is done frequently; even then, it will eventually seal. The need for vacuum cleaning makes this option more expensive for routine maintenance.

Maintenance/monitoring/enforcement considerations

a. Reliability and Consistency over Time
- All porous pavement designs will degrade in performance over time, with careful maintenance only incrementally increasing its operational lifespan.

b. Routine and Non-routine Maintenance
- Maintenance is minimal for modular block except when the surface becomes clogged. This will require expensive non-routine maintenance in the form of removing the blocks and the underlying clogged gravels. Routine (quarterly) vacuum sweeping and high pressure water washing of porous asphalt is required to prevent clogging. Non-routine maintenance consists of complete replacement, and may be required in as little as one year's time.
- When turf is used with modular block, lawn care maintenance is needed.
- Sand or ash should not be applied to porous pavement.
- Spot clogging of the porous pavement layer can be relieved by drilling 1/4" holes through the porous asphalt layer every few feet.

c. Sustainability of Maintenance or Program Management
- The obvious limitation is the need for expensive non-routine repairs or replacement. If privately owned, this expense may preclude necessary work. If publicly owned, there may be insufficient funds budgeted for maintenance.

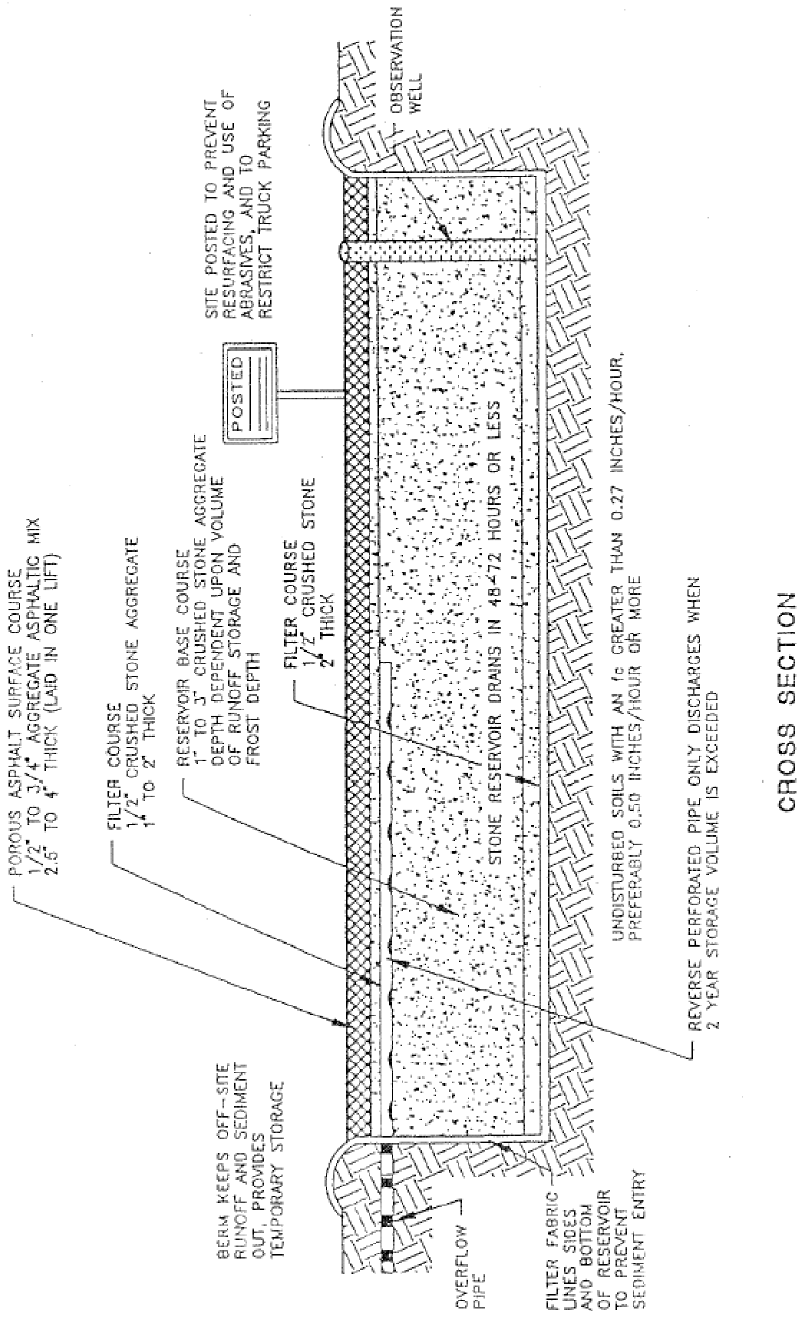
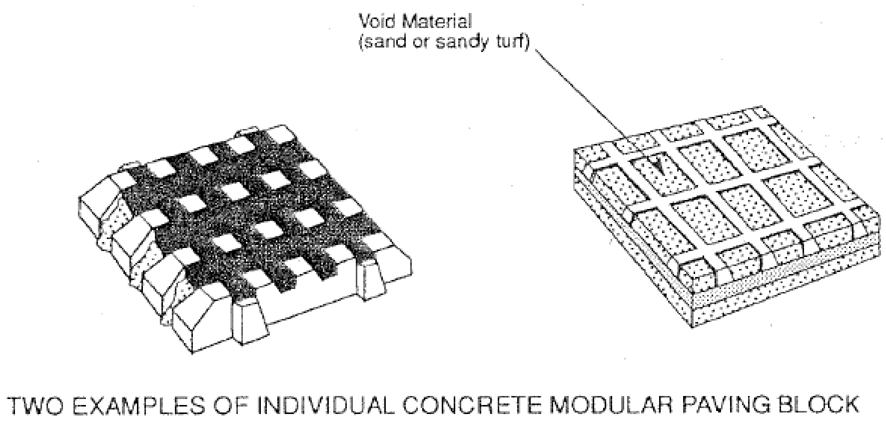


Figure 8-13 Design Schematic For Porous Pavement

Source: Controlling Urban Runoff



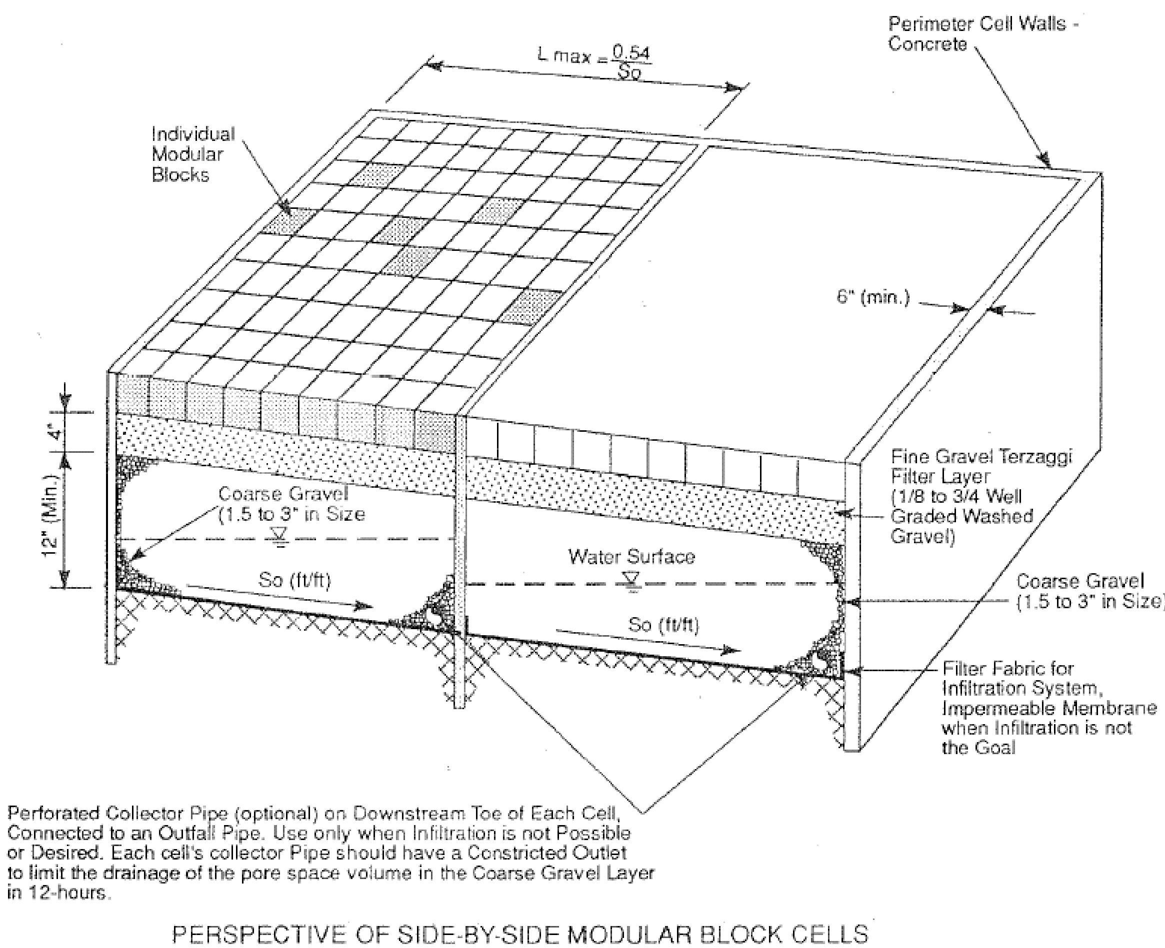


Figure 8-14 Design Schematic For Modular Block Porous Pavement

Source: Urban Drainage and Flood Control District, 1992

8.3.4.9 Oil/Grit Separators

Also known as a water quality inlet, an oil and grit separator is a three-stage underground retention system designed to remove heavy particulates and hydrocarbons from runoff. The first chamber allows for sedimentation. The second chamber has an inverted elbow for an outlet, such that oil is trapped at the surface. The third chamber directs the water out.

General applicability and experience with technique elsewhere

a. Typical Applications
- This BMP was originally designed for industrial applications, rater than urban storm water applications. When translating to a storm water BMP, two problems arise: (1) an expectation of removal of pollutants other than oil and grit is created; and (2) widely varied flows can overwhelm and make ineffective a BMP that was designed for steady low flows and not "flashy" high flows.
- The most effective use of this BMP is in capturing runoff from small, high density sites where high concentrations of oils in runoff are expected.
- Oil/Grit separators are most frequently used in highly urbanized areas where other BMPs cannot be used due to space limitations.

b. Design Considerations (See Figure 8-15 for representative schematic)
- Tributary area is usually limited to two acres or less of mostly impervious surfaces. This is primarily a water quality rather than quantity mitigation BMP.
- Separator should be structurally sound and designed for acceptable traffic loadings where subject to traffic loadings.
- Separator should be designed to be water tight.
- Volume of separator should be at least 400 cubic feet per acre tributary to the facility (first two chambers).
- Forebay or first chamber should be designed to collect floatables and larger settleable solids. Its surface area should not be less than 20 square feet per 10,000 square feet of drainage area.
- Oil absorbent pads, oil skimmers, or other approved methods for removing accumulated oil should be provided.
- Separator pool should be at least 4 feet deep.
- Manholes should be provided to each chamber to provide access for cleaning.
- Separator to be located close to the source before pollutants are conveyed to storm sewers or other BMPs.
- Use only on sites of less than one acre.
- Provide perforated covers as trash racks on orifices leading from first to second chamber.

c. Other Experiences with BMP
- Experience demonstrates that these have limited pollutant removal ability with resuspension of trapped particulates common. Since residues tend to be toxic, disposal is a problem. As a result, there are no current clean-out and disposal procedures.

Reported pollutant removal efficiencies

- Pollutant removal ability is limited. This is due to the lack of clean-out and disposal procedures and the tendency for trapped sediments to resuspend. One study (Shepp et al. 1992) showed that the depth of trapped sediments in over 120 separators was less than two inches. More than eighty percent of the sediments were coarse-grained grit and organic matter. Additionally, the amount of trapped sediment did not correlate with age, indicating that resuspension is a common failure mode. Sediments that were trapped were very oily in nature.
- The positive aspect to this BMP is that examination of the sediments shows that the adsorbed pollutants match those found in receiving water bodies, indicating that the right target pollutants are being addressed.

- Three chamber oil and grit devices may remove from 60 to 80 percent of the hydrocarbons found in parking lot and street runoff.
- Three chamber oil and grit devices may also remove a small portion of the suspended sediment and trace metal loads.

Advantages

- Can be used in highly urbanized areas where other BMPs cannot be used.
- Trapping of floatable trash and debris and possible reduction of hydrocarbon loadings from impervious areas.
- They do not rely on infiltration, so that direct input of runoff into the ground water is unlikely.

Disadvantages

a. Human Risk, Public Safety and Potential Liability
   - The trapped sediments are highly toxic (organics)
b. Environmental Risk and Implications
   - Trapped sediments are highly toxic and cannot be easily disposed of, resulting in the generation of a toxic waste.
   - Large storm events can cause resuspension of trapped solids, resulting in a pulse of very poor quality effluent.
c. Other
   - The lack of a practical disposal method for the toxic sediments results in improper maintenance that causes failure of the system.

Maintenance/monitoring/enforcement considerations

a. Reliability and Consistency over Time
   - Pollutant removal performance likely drops off very quickly after a few months.
b. Routine and Non-routine Maintenance
   - Sediments are toxic and cannot be landfilled; therefore, maintenance involves only the removal of floatables.
   - Cleaning on a quarterly basis should be a minimum schedule with more intense land uses such as gas stations requiring cleaning as often as monthly.
   - Cleaning should include pumping out waste water and grit and having the water processed to remove oils and metals.

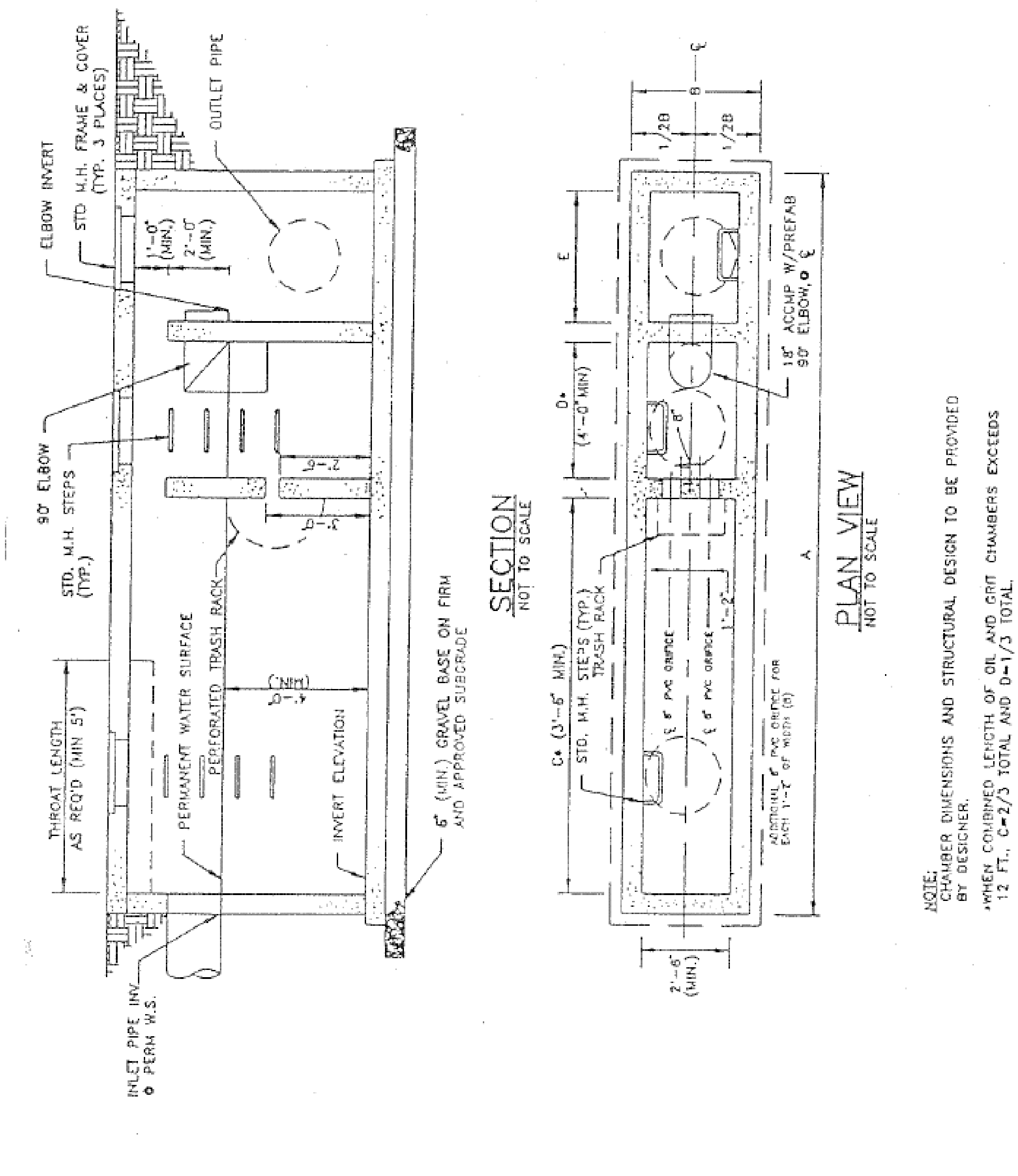


Figure 8-15 Oil/Grit Separator

Source: Maryland Department Of The Environment Sediment And Stormwater Administration

8.3.4.10 Grate Inlet Inserts

Grate inlet inserts are a newer type of oil/grit separator consisting of an insert that fits inside a standard grate inlet. Normally the inserts are made of a stainless steel, aluminum or cast iron framework which sits on the lip of the inlet grate frame and hangs down into the catch basin inlet chamber. One or more trays of filtration media are placed into the framework. The top screen or tray is usually a sediment trap. The flow enters the top of the filtration tray and filters through. Filtering media can be made of activated charcoal (for pesticides, fertilizer and metals removal), reconstituted wood fiber (primarily for oil and grease) or household fiberglass insulation. Excess flow beyond the capacity of the media bed or due to media clogging is routed over the sides of the tray(s) and out through the bottom or side of the framework. The capacity of the overflow is designed to equal or exceed the capacity of the grate.

One or more trays of filtering media, sometimes of different types, are then placed either stacked or in a rack below the sediment trap and screen. The media can be disposed in a manner similar to oil and grit chamber sediment though it may need to be tested once to see if it is a hazardous waste.

General applicability and experience with technique elsewhere

a. Typical Applications
- These can be used in most places where catch basins are installed.
- It appears to be an ideal application for retrofitting such areas as parking lots, gas stations, vehicle maintenance areas, "dirty" neighborhoods or industrial areas, etc.

b. Design Considerations
- Several companies produce such inserts, or they can be fabricated from common materials. The materials which make up the framework and the trays should be highly resistant to corrosion, easy to install manually and fit standard inlets.

Reported pollutant removal efficiencies

- Pollutant removal rate information is limited to a few installations, some bench tests and visual inspections. But it appears to be quite high for oil and grease and metals (above 80%-90%) (Debo, 1994).

Advantages

- It is easy to install (may take as little as 15 minutes), relatively inexpensive, requires no construction or modifications of existing catch basins, easy to maintain by property owners, and is targeted toward the major pollutants from these areas.

Disadvantages

a. Human Risk, Public Safety and Potential Liability
- Similar to conventional catch basins

b. Environmental Risk and Implications
- Difficult to quantify, but should be significantly improved over conventional basins.

Maintenance/monitoring/enforcement considerations

a. Reliability and Consistency over Time
- Unknown, but proper maintenance should provide a reasonable lifetime vs. costs. There is some question concerning the chemical integrity and longevity of the fiberglass in harsher environments.

b. Routine and Non-routine Maintenance

- Maintenance requirements include inspecting the flow integrity of the system and replacement of the filtration media. Quarterly replacement is a good starting estimate though the installations should be checked after wet periods and periodically.

c. Sustainability of Maintenance or Program Management

- Routine maintenance is required and must be built into the cost estimate for the system.

8.4 Nonstructural Best Management Practices

Previous sections of this chapter presented the details of structural best management practices and their use within the municipal drainage system. The other major category of BMPs include the many nonstructural or source control practices that can be used for pollution prevention and control of pollutants. In most cases it is much easier and less costly to prevent the pollutants from entering the drainage system than trying to control pollutants with structural BMPs. Thus within the "treatment train" concept, the nonstructural BMPs should be the first line of defense in protecting the receiving stream within the municipality. If used properly, the nonstructural BMPs can be very effective in controlling pollutants and greatly reduce the need for structural BMPs. In addition, nonstructural BMPs tend to be less costly, easier to design and implement and easier to maintain than structural BMPs. The following is a brief discussion of some nonstructural BMPs that can be used in the Lincoln area.

8.4.1 Public Education/Participation

Public education/participation is not so much a best management practice as it is a method by which to implement BMPs. Public education/participation are vital components of many of the individual source control BMPs. A public education and participation plan provides the municipality with a strategy for educating its employees, the public, and businesses about the importance of protecting stormwater from improper use, storage, and disposal of pollutants. It is important that residents become aware that a variety of hazardous products are used in the home and that their improper use and disposal can pollute stormwater and groundwater supplies. Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, must be informed of ways to reduce their potential to pollute stormwater.

The public education and participation plan should be based on four objectives:

- promote a clear identification and understanding of the problem and the solutions,
- identify responsible parties and efforts to date,
- promote community ownership of the problems and the solutions, and
- integrate public feedback into program implementation.

Target audiences include:

- Political - elected officials, chambers of commerce, and heads of departments, agencies, and commissions;
- Technical - municipal department and agency staffs, State agencies;
- Business - commercial and industrial, including trade associations;
- Community Groups - fraternal, ethnic, hobby, horticulture, senior citizen, and service;
- Environmental;
- General Public/Residential;
- Schools/Youth Groups;
- Media - print and electronic, and
- Pollutant-defined - groups of individuals defined by the specific pollutant(s) they discharge (e.g., used motor oil, pesticides)

For these target audiences the activities within the public education/participation plan can include surveys, presentations, school activities, development of working committees, development of literature and media campaigns, workshops, etc. All of these activities can be an important part of controlling local stormwater management problems.

8.4.2 Land Use Planning/Management

This BMP presents an important opportunity to reduce the pollutants in stormwater runoff by using a comprehensive planning process to control or prevent certain land use activities in areas where water quality is sensitive to development. It is applicable to all types of land use and represents one of the most effective pollution prevention practices. Subdivision regulations, zoning ordinances, preliminary plan reviews and detailed plan reviews, are tools that may be used to mitigate stormwater contamination in newly developing areas. Also, master planning, cluster development, terracing and buffers are ways to use land use planning as a BMP in the normal design for subdivisions and other urban developments. These are planning tools that municipal agencies can use to require conditions of approval or establish improvement/construction standards to meet the water quality objectives within specific watersheds.

An impervious cover limitation is one of the more effective land use management tools, since nationwide research has consistently documented increases in pollution loads with increases in impervious cover.

In addition, directly connected impervious areas should be kept to a minimum. This is especially important for large impervious areas such as parking lots and highways and it can also be effective for small impervious areas such as roof drainage. Minimization of impervious cover within a development is encouraged.

8.4.3 Material Use Controls

There are three major BMPs included in this category:

1. Housekeeping Practices
2. Safer Alternative Products
3. Pesticide/Fertilizer Use

In housekeeping practices, the goal is to promote efficient and safe practices such as storage, use, cleanup, and disposal, when handling potentially harmful materials such as fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals. Alternatives exist for most product classes including fertilizers, pesticides, cleaning solutions, and automotive and paint products, and thus the use of less harmful products should be encouraged.

Pesticides and fertilizers have become an important component of land use and maintenance for municipalities, commercial land uses and residential land owners. Any usage of pesticides and fertilizers increases the potential for stormwater pollution. BMPs for pesticides and fertilizers include education in their use, control runoff from affected areas, control times when they are used, provide proper disposal areas, etc.

For the general public, public education provides information on such items as stormwater pollution and the beneficial effects of proper disposal on water quality; reading product labels; safer alternative products; safe storage, handling, and disposal of hazardous products; list of local agencies; and emergency phone numbers. This information can be provided through brochures or booklets that can be made available at a variety of places including municipal offices, public information fairs, and places where such products are sold. Education should also be developed for municipal employees and commercial and industrial establishments.

8.4.4 Material Exposure Controls

Material storage control is used to prevent or reduce the discharge of pollutants to stormwater from material delivery and storage by minimizing the storage of hazardous materials onsite, storing materials in a designated area, installing secondary containment, conducting regular inspections, and training employees and subcontractors.

8.4.5 Material Disposal And Recycling

There are three major BMPs included in this category:

1. Storm Drain System Signs
2. Household Hazardous Waste Collection
3. Used Oil Collection

Stenciling of the storm drain system (inlets, catch basins, channels, and creeks) with prohibitive language/graphic icons discourages the illegal dumping of unwanted materials. This is an ongoing effort within the City of Lincoln.

Household hazardous wastes are defined as waste materials which are typically found in homes or similar sources, which exhibit characteristics such as: corrosivity, ignitability, reactivity, and/or toxicity, or are listed as hazardous materials by the EPA.

Used oil recycling is a responsible alternative to improper disposal practices such as dumping oil in the sanitary sewer or storm drain system, applying oil to roads for dust control, placing used oil and filters in the trash for disposal to landfill, or simply pouring used oil on the ground.

Storm drain system signs act as highly visible source controls that are typically stenciled directly adjacent to storm drain inlets. The signs contain brief statements that discourage the dumping of improper materials into the storm drain system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message. The intent of such a storm drain system stenciling program is to enhance public awareness of the pollutant effect on local receiving waters from stormwater runoff and also to discourage individual's habitual waste disposal actions (e.g., automotive fluids and landscaping wastes). An important aspect of a stenciling program is the distribution of informational flyers that educate the neighborhood (business or residential) about stormwater pollution, the storm drain system, and the watershed, and that provides information on alternatives such as recycling, household hazardous waste disposal, and safer products.

While it is generally recognized that the potential exists for hazardous household materials to come in contact with stormwater runoff, it is unclear at present how significant this source of contamination is. As such, it is difficult to quantify the benefits to water quality from household hazardous waste collection programs. However, such programs are a preventative, rather than curative measure, and may reduce the need for more elaborate treatment controls. Programs can be a combination of permanent collection centers, mobile collection centers, curbside collection, recycling, reuse, and source reduction. Public education is extremely important in implementing this BMP.

8.4.6 Spill Prevention And Cleanup

There are two major BMPs included in this category:

1. Vehicle Spill Control
2. Aboveground Tank Spill Control

The purpose of a vehicle spill control program is to prevent or reduce the discharge of pollutants to stormwater from vehicle leaks and spills by reducing the chance for spills by preventive maintenance, stopping the source of spills, containing and cleaning up spills, properly disposing of spill materials, and training employees. It is also very important to respond to spills quickly and effectively.

Aboveground tank spill control programs prevent or reduce the discharge of pollutants to stormwater by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques.

Accidental releases of materials from aboveground liquid storage tanks present the potential for contaminating stormwater with many different pollutants. Materials spilled, leaked, or lost from tanks may accumulate in soils or on impervious surfaces and be carried away by stormwater runoff.

Proper handling and storage of materials is very important and should include proper labeling; development of storage and handling procedures, secondary containment procedures, spill response procedures; and adequate training and education for those involved with this BMP.

8.4.7 Dumping Controls

This BMP addresses the implementation of measures to detect, correct, and enforce against illegal dumping of pollutants on streets and into the storm drain system, streams, and creeks. Substances illegally dumped on streets and into the storm drain system and creeks include paints, used oil and other automotive fluids, construction debris, chemicals, fresh concrete, leaves, grass clippings, and pet wastes. All of these wastes can cause stormwater and receiving water quality problems as well as clog the storm sewer system itself. Increased coordination with Lancaster County Health Department efforts would be useful.

8.4.8 Connection Controls

There are three major BMPs included in this category:

1. Illicit Connection Prevention
2. Illicit Connection Detection and Removal
3. Leaking Sanitary Sewer Control

Illicit connection protection tries to prevent unwarranted physical connections to the storm drain system from sanitary sewers, floor drains, etc., through regulation, regular inspection, testing, and education. In addition, programs include implementation control procedures for detection and removal of illegal connections from the storm drain conveyance system. Procedures include field screening, follow-up testing, and complaint investigation.

Leaking sanitary sewer control includes implementing control procedures for identifying, repairing, and remediating infiltration, inflow, and wet weather overflows from sanitary sewers into the storm drain conveyance system. Procedures include field screening, testing, and complaint investigation.

Illegal connections can occur in new as well as existing developments. Improper connections in areas of new development can be prevented through inspection and other verification techniques. The first measure to prevention is to make sure that existing municipal building and plumbing codes prohibit any unwarranted, non-permitted physical connections to the storm drain system. Building and plumbing code inspectors, in addition to new land development project inspectors, must visually inspect to ensure that illegal connections are not being physically tied to the storm conveyance system. Proper documentation and record keeping is essential to the function of such inspections. Documentation helps catalog the storm drain system and is required by Federal regulations. Visual inspection, however, is not a very reliable means of verifying the status of new physical connections and their final destination. Continued monitoring throughout the entire development phase would be necessary to guarantee the new physical connections between the sanitary sewers and storm drains had been prevented through the inspection process.

Public education programs will also aid in the monitoring of illegal connections and leaking sanitary sewers by making individuals aware of evidence of unwarranted discharges to the storm drain system. A community hotline for reporting such evidence can greatly supplement the stormwater department's field screening efforts.

8.4.9 Street/Storm Drain Maintenance

There are seven major BMPs included in this category:

1. Roadway Cleaning
2. Catch Basin Cleaning
3. Vegetation Controls
4. Storm Drain Flushing
5. Roadway/Bridge Maintenance
6. Detention/Infiltration Device Maintenance
7. Drainage Channel/Creek Maintenance

Roadway cleaning may help reduce the discharge of pollutants to stormwater from street surfaces by conducting cleaning on a regular basis. However, cleaning often removes the larger sizes of pollutants but not the smaller sizes.

Most pollutants accumulate within three feet of the curb which is where the roadway cleaning should be concentrated. Catch basin cleaning on a regular basis also helps reduce pollutants in the storm drain system, reduces high pollutant concentrations during the first flush of storms, prevents clogging of the downstream conveyance system and restores the catch basins' sediment trapping capacity.

Vegetation control typically involves a combination of chemical (herbicide) application and mechanical methods. Mechanical vegetation control includes leaving existing vegetation, cutting less frequently, handcutting, planting low maintenance vegetation, mulching, collecting and properly disposing of clippings and cuttings, and educating employees.

Storm drains can be "flushed" with water to suspend and remove deposited materials. Flushing is particularly beneficial for storm drain pipes with grades too flat to be self-cleansing. Flushing helps ensure pipes convey design flow and removes pollutants from the storm drain system. However, flushing will only push the pollutants into downstream receiving waters unless the discharge from the flushing is captured and removed from the drainage system.

Proper maintenance and siltation removal is required on both a routine and corrective basis to promote effective stormwater pollutant removal efficiency for wet and dry detention ponds and infiltration devices. Also, regularly removing illegally dumped items and material from storm drainage channels and creeks will reduce pollutant levels.

8.4.10 Permanent Erosion Control

There are three major BMPs included in this category:

1. Erosion Control - Permanent Vegetation
2. Erosion Control - Flow Control
3. Erosion Control - Channel Stabilization

Vegetation is a highly effective method for providing long term, cost effective erosion protection for a wide variety of conditions. It is primarily used to protect the soil surface from the impact of rain and the energy of the wind. Vegetation is also effective in reducing the velocity and sediment load in runoff sheet flow.

Channel stabilization addresses the problem of erosion due to concentrated flows. Concentrated flows occur in channels, swales, creeks, rivers and other water courses in which a substantial drainage area drains into a central point. Overland sheet flow begins to collect and concentrate in the form of rills and gullies after overland flow length of as little as 100 feet. Erosion due to concentrated flow is typically extensive, causing large soil loss, undermining foundations and decreasing the flow capacity of watercourses.

Proper selection of ground cover is dependent on the type of soil, the time of year of planting, and the anticipated conditions that the ground cover will be subjected. In addition, mulching is a form of erosion protection which is commonly used in conjunction with establishment of vegetation. It typically improves infiltration of water, reduces, retards erosion and helps establish plants in disturbed areas.

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